PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : F42B 12/74

A1

(11) International Publication Number: WO 00/37878

(43) International Publication Date: 29 June 2000 (29.06.00)

(21) International Application Number: PCT/US99/31016

(22) International Filing Date: 23 December 1999 (23.12.99)

(30) Priority Data:
09/220,087 23 December 1998 (23.12.98) US

(71)(72) Applicant and Inventor: BEAL, Harold, F. [US/US]; 6277 Sierra Circle, Rockford, TN 37853 (US).

(74) Agent: HODGES, Paul, E.; Pitts & Brittian, P.C., P.O. Box 51295, Knoxville, TN 37950 (US).

(81) Designated States: CA, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: SMALL BORE FRANGIBLE AMMUNITION PROJECTILE

(57) Abstract

A fully frangible projectile for a small bore weapon, including a core formed from a mixture of powders into a core blank of high uniform density. The core blank is die–formed to an undersize core and thereafter provided with a plate on the outer surfaces thereof. The plated core is restruck to adjust its frangibility and intimately associate the plate with powder particles exposed on the external outer surfaces of the core such that disintegration of the core effects like disintegration of the plate. A method for the manufacture of the projectile is disclosed.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

SMALL BORE FRANGIBLE AMMUNITION PROJECTILE

FIELD OF INVENTION

This invention relates to ammunition, and particularly to a frangible projectile for use in small bore ammunition for weapons having a rifled barrel, especially pistols.

BACKGROUND OF INVENTION

A projectile for a small bore, i.e., .50 caliber or less, weapon having a rifled barrel, commonly, has heretofore been formed from lead. Lead, and similar soft metal projectiles tend to leave deposits of the metal within the barrel of a weapon as the projectile is propelled along the barrel during firing of the weapon. In the prior art, it has been a common practice to encase the lead projectile in a copper jacket to eliminate contact of the lead with the lands and/or inner wall of the weapon barrel, and thereby eliminate the lead deposits within the barrel. These copper jackets are commonly preformed, loaded with a lead core, and thereafter die formed to shape the core and jacket into the desired geometry for the projectile. It has also been practiced to electroplate a copper coating on the exterior surface of the lead core. U.S. Patent No. 5,597,975 references certain prior copper-plating art and discloses a further plating process for ammunition projectiles. Notably, the cores of these prior art projectiles are not intended to be frangible.

In known prior art jacketed ammunition projectiles, it has been the intent that the jacket play a material part in the destructive force delivered by the projectile to a target. Accordingly, in the prior art, commonly the jackets are locked

onto the core by various mechanical interlocks between the jacket and core. In similar manner, heretofore, the prior art teaches that coatings applied to cores for use in forming projectiles should be strongly adhered to the core and should perform a destructive function upon the projectile striking a target. Hollow point type projectiles are of this type.

Because of environmental concerns relating to lead, much effort has been expended in the development of projectiles which do not contain lead. This effort has attempted to fabricate a projectile which, when fired from a weapon, responds precisely like a lead projectile. Combinations of various heavy metal powders with lighter metal powders that function as binders for the heavy metal powders have been suggested. Among these combinations it has been suggested that tungsten powder be combined with tin powder and cold-pressed into a projectile. Other similar powder combinations have been suggested.

One problem associated with the use of heavy metal powders is their tendency to erode a weapon barrel due to their hardness and abrasiveness. The prior art approach to solving this problem has been to encase a powder-based core in a jacket of a relatively soft metal, such as copper. These prior art cores are essentially solid, some being sintered, and perform as if they were solid. Aside from his own work with powder-based cores, the present inventor is not aware of any successful fully frangible powder-based projectile for a small bore weapon. In fact, the many problems associated with plating a porous object, such as a powder-based core which is also frangible, are believed to lead one skilled in the art away from plating of frangible heavy metal powder-based cores. "Fully frangible" is defined as being disintegratable, upon impact of the projectile with a semi-solid or solid target, into individual particulates that are of a size on the order

of the particle size of that powder in the core that has the largest particle size.

More particularly, the known prior art coatings and/or jackets for solid core projectiles teaches that the coating or jacket should strongly adhere to the core and only fragment in the form of large chunks or pieces which allegedly increase the destructive power imparted to a target upon it being struck by the projectile. In the instance where the projectile desirably is frangible, the prior art jackets and coatings for cores are not known to disintegrate into relatively minute particulates, hence are less than desirable for use where full frangibility of the projectile is desired or required.

In certain law enforcement or warfare circumstances, it is highly desirable that a fired projectile does not ricochet. Ricocheting projectiles endanger both friendly forces and innocent bystanders. In these circumstances, it often also is desired that the projectile penetrate an animal or human target and leave an open channel through the target. This result most commonly takes the target out of commission, but may not be lethal. This desired result generally conflicts with the desire that the fired projectile should not ricochet.

SUMMARY OF INVENTION

Contrary to the prior art, the present inventor has developed a projectile that includes a heavy metal powder-based core which is plated with a relatively light (soft) metal and which exhibits unusual performance characteristics when it strikes a target. Specifically, the projectile of the present invention has been found to penetrate a soft tissue target, leaving the usual channel through the target, but which will disintegrate readily when the projectile strikes a

semi-solid or solid object such as cartilage, bone or the like associated with the primary target. Importantly, should the projectile fully penetrate the target, upon its first impact with a semi-solid or solid object external of the intended target, it fully disintegrates harmlessly. The disintegration action externally of the intended target, fully involves both the core and the plated coating thereon, each of these components being dissipated over very short distances as harmless minute particulates.

In accordance with one aspect of the present invention, the core of the present projectile comprises tungsten metal powder mixed with tin metal powder and a fine particle size oxidized polyethylene polymer and cold-compacted into a self-supporting core. This core is thereafter plated with a coating of copper or other like relatively light metal in a plating solution which is free of plating chemicals which can be absorbed by the somewhat porous core and later leach out to discolor the plate. Cyanide is especially to be avoided in the plating solution. The coating of the present invention further is of a thickness which provides the desired lubricity of the projectile as it moves through the weapon barrel and which is not destroyed during flight of the projectile to its target. Particularly, the coating of the present invention will withstand the very large centrifugal forces associated with the spinning of the projectile at greater than 100,000 rps so as to preclude breakup of the projectile prior to reaching its target, and which will provide penetrating power to the projectile at the target, and further will fully and effectively disintegrate upon striking a semi-solid or solid target.

It is therefore an object of the present invention to provide a frangible powder-based externally plated ammunition projectile for small bore weapons having a rifled barrel.

It is another object of the present invention to provide a frangible projectile which is capable of penetrating a soft tissue or like target and which will fully disintegrate upon striking a semi-solid or solid target.

It is another object of the present invention to provide a frangible projectile which exhibits accuracy of delivery equivalent to a lead-based projectile of the same caliber.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a representation of one embodiment of a cold-compacted powder-based core blank embodying various of the features of the present invention;

Figure 2 is a representation of one embodiment of an undersized core formed from a core blank of the kind depicted in Figure 1;

Figure 3 is a representation of a core as depicted in Figure 2 and including a plated coating on the outer surface thereof; and

Figure 4 is a flow diagram of one embodiment of a method for the manufacture of the present projectile.

DETAILED DESCRIPTION OF INVENTION

With reference to the Figures, the core 18 of the present projectile 14 is metal powder-based, meaning that the core is made up of a mixture that is predominately metal powders. In the present invention, the preferred metal powders are tungsten powder and tin powder. Whereas it is preferred that the mixture be tungsten-based, that is, it contains 50% or more, by weight, of tungsten powder, it is acceptable in the

manufacture of projectiles intended for special applications that tungsten powder be less than 50% by weight. In the preferred embodiment of the present projectile, the second metal powder in the mixture is tin powder. For most applications of use of the present projectile, the percentage of tungsten powder may range from about 40% to about 80%, by weight with the remainder of the mixture being tin, except for about 0.10%, by weight, of a fine particle size oxidized polyethylene homopolymer, such as that provided by AlliedSignal, Inc., of Morristown, NJ and known as ACumist A-12. This powder is of a -250 +400 mesh. Mixtures of these powders within the stated ranges provide a projectile having a density materially greater than lead, e.g. about 13-14 grams per cubic centimeter (g/cm^3).

The preferred tungsten powder exhibits a particle size of about -10 and +70 mesh and is the C and M series available from Osram Sylvania of Morristown, NJ. A tin powder of predominately -325 mesh, and having a substantial portion of -250 +325 mesh particles, such as Grade TC-125 available from Pyron Metal Products, Greenback, TN, may be employed.

In accordance with one aspect of the present invention, the core blank 16 is formed by compaction of the mixture of powders at ambient temperature, termed "cold-compaction" herein. The temperature at which compaction is effected may range below or above room temperature, but preferably does not exceed the melting point of tin. Within this range of temperatures, the tin is sufficiently ductile as permits it to be squeezed between the tungsten powder particulates and serve as a binder that holds the tungsten particulates together in a predetermined geometrically shaped core. Recognizing the several requirements imposed upon the powders employed in the present projectile, it will be recognized by one skilled in the art that a powder other than tin, such as lead, may be

substituted into the mixture, or a further metal powder may be added to the mixture as desired. Any of these substitutions or additions, however, are subject to altering the overall density and or ductility of the core and therefore may be less desirable. Typically, the core formed in this die-forming operation has a density of about 90% of its theoretical density. This loss of density from the core blank to the die-formed core is indicative of porosity within the core. The core, nonetheless, exhibits sufficient self-supporting strength as to permit the core to be mechanically handled in further manufacturing operations, including transport, tumbling in solution, etc.

It will recognized that tungsten powder particulates are very hard and very abrasive. Tungsten particulates are difficult to bond into a self-supporting body. As noted, bare tungsten projectiles will very quickly destroy a gun barrel due to abrasion of the bore of the barrel by the projectile which is propelled through the bore of the weapon. These properties of the tungsten powder also cause it to be difficult to die-form. High forming pressures, e.g. 50,000 psi, have been found to be necessary for forming tungsten/tin or tungsten/lead powder particulates into a body that will be sufficiently self-supporting for enduring subsequent manufacturing operations and possess a high density that is uniform throughout the core blank. At these high pressures in a die-forming operation, it becomes very difficult to extract the formed core blank from the die, hence the addition of polyethylene powder into the mixture of metal powders.

In accordance with a further aspect of the method of the present invention, the core blank 16 is formed into a core 18. This manufacturing operation may take different forms, but in any event, the core blank is die-formed one or more times during which bonds between the powder particles of the core

blank are partially disrupted or destroyed. Thereafter, in one embodiment, a minimum reestablishment of the powder particle bonds is sought. The steps in the method are depicted in the flow diagram of Figure 4.

In one embodiment of the present invention, the core blank 16 is die-formed into a core 18 (see Figure 2) which is of the desired general shape desired for the final projectile, but which is undersized at least in diameter (caliber) relative to the desired final diametral dimension (caliber) of the projectile being formed. The extent of undersizing of the core is a function of the rifled weapon from which the projectile is intended to be fired. Specifically, the extent of undersizing is substantially directly proportional to the height of the lands within the bore of the weapon barrel.

The pressure employed during this die-forming operation is sufficient to disrupt and/or destroy bonds between the powder particles of the core blank such that the core blank is caused to conform to the cavity of the die. Pressure of at least about 48,000 psi, and preferably about 50,000 psi is employed in this die-forming operation. Further, in this initial operation of forming the core, the pressure is sufficient to cause reestablishment of such bonding between the powder particles of the newly formed core as will permit the mechanical handling of the core during further manufacturing operations, e.g., electro or chemical plating of a soft metal plate onto the entire external outer surface of the undersized core.

Thereafter, the die-formed undersized core 18 is plated on its exterior surface with a thin layer (i.e. plate) 20 of a relatively soft metal. Copper is a preferred metal for plating onto the core. Preferably, the copper plating solution employed is free of cyanide inasmuch as the inventor has found

that the somewhat porous core retains in its pores a portion of the plating solution, and this solution tends to leach out of the core over time and react with the copper plate to produce unacceptable discoloration of the copper plate.

Plating of a soft metal onto a metal core is well known in the art (U.S. Pat. No. 5,597,975, for example). Generally, the cores are cleaned and thereafter plated employing a conventional plating method which preferably does not include cyanide in the plating solution. The various plating conditions, such as temperature, time, etc. are selected to lay down a layer of soft metal plate that uniformly plates the exterior surfaces of the core with a soft metal plate that is of a thickness which is slightly greater than the height of the land of the rifling of the weapon from which the projectile is intended to be fired. Commonly, the thickness of the multilayered plate is about 0.004 inch, but may range upward to about 0.025 inch. If the thickness of the plate is less than the height of the land which is to be involved, the plate deteriorates in the course of its movement along the length of the barrel of the weapon, thus exposing the land to the destructive abrasiveness of the high density powder from which the core is fabricated. By way of example, the core for a 9 mm projectile is initially sized to .3547 inch in outer diameter. A plate of .004 inch thickness is thereafter applied to this core.

Inasmuch as too great a thickness of the plate may cause the projectile to jam in the barrel of the weapon, or preclude chambering of the projectile in the weapon, following application of the plate onto the core, the plated core is restruck in a still further die. This latter die is internally sized to the precise dimensions desired for the final form and caliber of the projectile. Employing pressures of about 50,000 psi, this restriking of the plated core

appears to perform multiple functions. First, it functions to precisely size the projectile, including any needed adjustment to the geometry, especially the outer diameter of the projectile. A result of this resizing is some crushing of the powder-based core, thereby making the core more susceptible to disintegration, i.e., fully frangible, upon it striking a semi-solid or solid target. In this sizing operation, there is minimum reestablishment of the powder particle bonds so that the core loses a substantial portion of its density, e.g. the density of the core is about 90% or less of the theoretical density of the core. Second, this restriking operation performed upon the plated core also has been noted to integrate the plate with the core itself, thereby likely enhancing the disintegration of the plate upon disintegration of the core. That is, the strong and hard (e.g., tungsten) powder particles adjacent to the outermost core particles appear to be somewhat embedded within the softer metal of the plate such that the disintegrating powder particles adjacent the plate tend to tear away, and carry with them, very small portions of the plate as the powder particles dissipate. Firing tests of the present projectile to a solid target produced little more than a dark spot on the target. No fragments of the plate larger than approximately the same order of size as the individual tungsten powder particles were noted, but rather the plate disintegrated into substantially nonvisually-identifiable particulates. Ricochet of the projectile, or of fragments thereof, is essentially eliminated. In crush tests performed on restruck projectiles of the present invention over a range of pressure values showed that the projectiles of the present invention collapsed at compressive pressures as low as about 200 psi, thereby indicating the relative frangibility of these projectiles.

Further projectiles of the present invention were loaded into rounds of ammunition for a pistol and fired. There was

no evidence of abrasion of the bore of the barrel of the weapon due to the movement of the projectiles through the barrel. Further, the projectiles were fired into various targets, including animal flesh whereupon the projectiles fully penetrated the soft tissue without disintegrating, but they fully disintegrated when they eventually struck a solid object. No projectile ricocheted. Further projectiles fired into the animal flesh were purposefully caused to strike bone in the flesh. Upon striking the bone, both the powder and the plate of the projectile immediately disintegrated into relatively minute individual particulates. Further projectiles of the present invention were fired into gel targets and collected. Notably, the present projectiles penetrated into the gel to an extent equivalent to, and in some instances greater than, jacketed powder-based projectiles of like caliber.

With specific reference to Figure 4, one embodiment of the method for the manufacture of a projectile of the present invention includes the steps of selecting a first powder, tungsten powder, for example; selecting a second powder, tin powder, for example; selecting a powdered polyethylene; blending these powders to form a mixture thereof; measuring a quantity of the blended powders into a core blank die; pressing the powders within the core blank die into a solid straight cylindrical core; removing the core blank from its forming die and inserting the core blank into a shaping and sizing die where the core blank is formed into an undersized core of a desired shape; removing the core from its forming die; plating at least one layer of a relatively soft metal onto the outer surfaces of the core; restriking the plated core in a final die whose cavity is dimensioned precisely to the desired final geometry and caliber of the projectile; and recovering the finished projectile.

WHAT IS CLAIMED:

Claim 1. A fully frangible projectile for a small bore weapon comprising

a first powder selected from tungsten, tungsten carbide or mixtures thereof,

a second powder selected from tin, zinc, bismuth, lead, iron or mixtures thereof,

a third powder comprising an organic polymer which is characterized by a fine particle size oxidized polyethylene homopolymer,

said first, second and third powders being blended together and thereafter cold-compacted into a self-supporting body having particulates of said first powder exposed on the exterior surface thereof,

a thin soft metal plate on the exterior surface of said body and being cold-compacted into intimate association with the first powder particulates exposed on the exterior surface of said body so that upon disintegration of said body, said plate is disintegrated into particulates having a particle size on the order of the particle size of the particulates of said first powder.

Claim 2. The projectile of Claim 1 wherein said body is die-formed at ambient temperature into an aerodynamically desired geometry.

Claim 3. The projectile of Claim 2 wherein the geometry of said body includes an outer diameter which is less than the

diameter of a standard projectile for a given caliber weapon.

Claim 4. The projectile of Claim 3 wherein said plate is of a thickness such that when the plated body is cold-compacted, the thickness of the plate is greater than the height of the land of the weapon from which the projectile is intended to be fired.

Claim 5. The projectile of Claim 1 wherein said third powder exhibits a mesh size of about -250 +400.

Claim 6. The projectile of Claim 5 wherein said third powder is a fine particle size oxidized polyethylene homopolymer.

Claim 7. The projectile of Claim 1 wherein said third powder is present in an amount of between about 0.10% and about 1.2%, by weight, said first powder is present in an amount of between about 40% and about 80%, by weight, and the remainder of the blended powders being said second powder.

Claim 8. The projectile of Claim 1 wherein said body has a density of about 90% of its theoretical density.

Claim 9. The projectile of Claim 1 wherein said first powder is tungsten.

Claim 10. The projectile of Claim 1 wherein said second powder is lead, tin or zinc.

Claim 11. The projectile of Claim 1 wherein said first powder is tungsten and said second powder is lead, tin or zinc.

Claim 12. The projectile of Claim 1 wherein said body has a crush strength of not greater than about 200 psi.

NOT TO BE TAKEN INTO ACCOUNT FOR THE PURPOSE OF INTERNATIONAL PROCESSING

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/31016

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :F42B 12/74
US CL :102/506
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 102/501,506,514-517,529 ; 29/1.22,1.23

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 96 01407 A (LOCKHEED MARTIN ENERGY SYSTEMS) 18 January 1996 (18/01/96), See entire document.	1-12
Y	US 1,732,211 A (OLIN ET AL) 15 October 1929 (15/10/29), See entire document.	1-12
Y	US 5,594,186 A (KRAUSE ET AL) 14 January 1997 (14/01/97) lines 45-48 of col 6 and line 13 of col. 7.	1-12
Y,E	US 6,048,379 A (BRAY ET AL) 11 April 2000 (11/04/2000), Fig 27, line 9 of col. 5 through line 56 of col. 11, table 34.	1-12
A	US 1,992,244 A (SCHURICHT) 26 February 1935 (26/02/35).	

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
02 MAY 2000

Date of mailing of the international search report
30 MAY 2000

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
HAROLD TUDOR
Telephone No. (703) 306-4172

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/31016

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3,349,711 A (DARIGO ET AL) 31 October 1967 (31/10/67).	
A	US 4,387,492 A (INMAN) 14 June 1983 (14/06/83).	
A	US 4,428,295 A (URS) 31 January 1984 (31/01/84).	
A	US 5,079,814 A (MOORE ET AL). 14 January 1992 (14/01/92)	
A	US 5,279,787 A (OLTROGGE) 18 January 1994 (18/01/94)	
A	US 5,597,975 A (SATOW) 28 January 1997 (28/01/97)	
A	GB 2,278,423 A (SLATOR ET AL) 30 November 1994 (30/11/94).	